# Modelling Human Support Agent for Managers During Stress



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***Abstract*—Patterns of stress at work become a popular topic and have been reported everywhere. Work related performance during stress is a pattern of reactions that occurs when managers are presented with work demands that are not matched with their knowledge, skills, or abilities, and which challenge their ability to cope. Although there are many prior findings pertaining to explain the development of manager performance during stress, less attention has been given to explain the same concept through computational models. In such, a descriptive nature in psychological theories about managers' performance during stress can be transformed into a causal-mechanistic stage that explains the relationship between a series of observed phenomena. This paper proposed a human support agent model for analyzing managers' performance during stress. Set of properties and variables are identified through past literatures to construct the model. Differential equations have been used in formalizing the model. Set of equations reflecting relations involved in the proposed model are presented. The developed model has been simulated by applying it to different scenarios. Mathematical analysis has been used for the evaluation of the model. Results showed that the support model is able to show the effects of different levels of stress on managers' performance. The proposed model is essential and can be encapsulated within an intelligent agent or robots that can be used to support managers during stress.**

***Index Terms*—Stress; Managers' Performance; Human Support Agent; Computational Model.**

## I. Introduction

Stress at work can influence one in making decision, especially in working environments. Work related performance during stress is a pattern of reactions that occurs when managers are presented with work demands that are not matched with their knowledge, skills, or abilities, and which challenge their ability to cope. These demands may be related to time pressure, the ammount of work, or the difficulty of the work. When the manager perceives an imbalance demands and environmental or personal resources, this can cause a number of possible reactions. These may include physiological responses (e.g. blood pressure, increase in heart rate), emotional responses (e.g. reduced attention, forgetfulness) and emotional responses (e.g. feeling nervous, irritated). In many situations, when managers are in a state of stress, they often feel concerned, less vigilant, and less efficient in performing crucial decision making tasks.

Although much of the research about relationship between stress and managers' performance focuses on the negative performance effects of stress, not all stress is bad. For example, the Yerkes-Dodson principle (widely known as in inverted U curve principle), explains that performance improves as stress increases until a point at which it decreases [1]. One of the key factors behind this concept is the relationship between performance and arousal, where stress has been associated with arousal. Research has found that different tasks require different levels of arousal for optimal performance.

There are many prior findings pertaining to explain the development of manager performance during stress, however less atention has been given to explain the same concept through computational models. Therefore, the implementation of a human-model can offer novel technical solutions to the acquisition of complex human functioning process [2]. In such, the descriptive nature in psychological theories about managers' performance during stress can be transformed into a causal-mechanistic stage that explains the relationship between a series of observed phenomena [3]. With this goal in mind, a human-agent model can be useful to serve as a foundation to design an intelligent software agent that can predict the optimal performance level and support manager when facing critical points to decide the right action during heighten stress [4]. The use of human agent model is regarded as a tool for internal and external investigation of cognition and psychology within investigated subject.

In this paper, a human support agent model for analysing managers' performance during stress is proposed. Second part of the paper discusses agent models and its strength. Methodology of constructing the model is covered in the third part of the paper. Simulation results presented in the fourth part, while concluding remarks are covered in the last section.

## II. Computational Model

Computational modeling refers to a process of simulating a set of processes that have been observed in the natural world in order to gain profound understanding of these processes and to predict the outcome of natural processes by given a specific set of input parameters. A constructed computational model is accomplished of simulating certain key behaviors in the particular area of interest and concern. In recent years, computational models are often used as tools for understanding human cognitive functions and behaviors [5], [6]. The models have been used to investigate the fundamental nature of various cognitive functionalities and psychology through the ongoing detailed comprehension by assigning identical computational models of representations and mechanisms. Moreover, this computational way that has been used to model cognitive functionalities of human is called cognitive modeling and known as “a method to study the human mind**.**

The intelligent agent technology is invaluable in maximizing analysis, decision making ability as well as interactions. In order to create a supportive human agent application, it is important to include a dynamic model of the human portraying the way how he may experience cognitive vulnerability or to maintain a healthy well-being into the application [7]. Different techniques have been used in developing computational models. However, differential equation technique is the most widely used technique in designing computational models.

## III. HUMAN SUPPORT MODEL

Four main phases involved in analyzing managers' performance during stress are; identification of properties, designing a conceptual model based on the identified properties, formalization in defining equations, and simulating the model.

Internal (local) and external (non-local) properties have been identified from past literatures, particularly from the main theories and models explained in Section 3. Local (internal) properties are the stress factors that represent internal factors to the managers. These factors are dependent on the psychology of the person and it contributes directly or indirectly to stress as a consequence affects the performance either positively or negatively. Non-local (external) properties are the stress factors in which are external to the managers and it affect the level of stress which would lead to changes on the performance levels. For the sake of clarity, the properties have been represented in two sets as instantaneous properties, and temporal properties.

External (non-local) properties, internal properties, level of stress, and types of performance which used in constructing a conceptual model are depicted in Table 1, Table 2, Table 3, and Table 4 respectively.

Table 1
External properties

| No | Property | Formal representation |
|---|---|---|
| 1 | Environment stressors | *En* |
| 2 | Job resources | *Jr* |
| 3 | Job demands | *Jd* |
| 4 | Social support | *Sc* |
| 5 | Cynicism | *Cy* |
| 6 | Negative personality factor | *NP* |

Table 2
Internal properties

| No | Property | Formal representation |
|---|---|---|
| 1 | Appraisal: Acceptance | *Ap* |
| 2 | Appraisal: Holdback | *Hb* |
| 3 | Coping: Emotional focus | *Ef* |
| 4 | Coping: Problem focus | *Pf* |
| 5 | Self-efficacy | *Se* |
| 6 | Job buffer | *Jb* |
| 7 | Motivation | *Mv* |
| 8 | Satisfaction | *Sa* |
| 9 | Dissatisfaction | *Ds* |
| 10 | Job strain | *Js* |

Table 3
Output

| No | Property | Formal representation |
|---|---|---|
| 1 | Short term stress | *Ss* |
| 2 | Short term exhaustion | *Sx* |
| 3 | Short term fatigue | *Sf* |
| 4 | Burnout | *Br* |
| 5 | Long term stress | *Ls* |
| 6 | Long term exhaustion | *Lx* |
| 7 | Long term fatigue | *Lf* |

Table 4
Performance

| No | Property | Formal representation |
|---|---|---|
| 1 | Short term job performance | *Sp* |
| 2 | Long term Job performance | *Lp* |

A conceptual model is constructed based on the properties (stressors) identified in the previous phase. This model represents a combination of internal and external properties, the resulted level of stress and job performance. Figure 1 shows the conceptual model of the study, which illustrates the relationships of each component, which later to be formalized. The model shows how stressors and level of stress will affect the managers' performance.

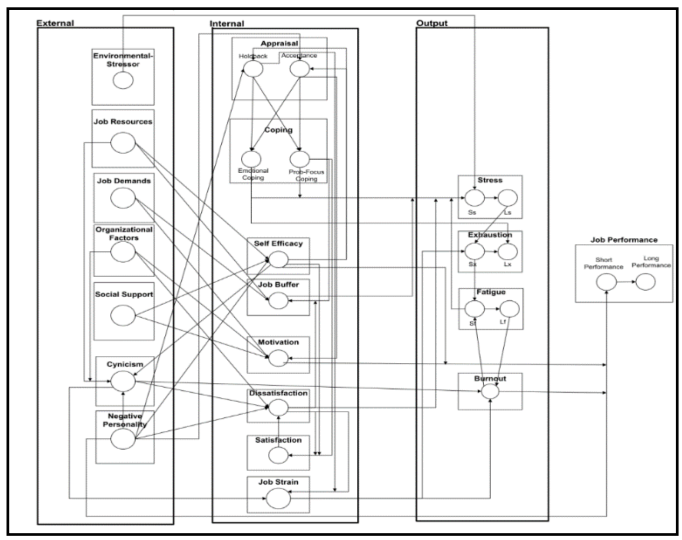


Figure 1: A proposed model

Differential equations have been used to formalize the model. There are twenty equations have been formalized, representing all relations in the proposed model. For example, cynicism in external properties will be calculated as:

$$\mathrm{Cy(t)} = \mathrm{Np(t)}.\left[1 - \left(\omega_{cy1}.\mathrm{Jr(t)} + \omega_{cy2}.\mathrm{Of(t)} + \omega_{cy3}.\mathrm{Se(t)} + \omega_{cy4}.\mathrm{Pf(t)}\right)\right] \quad (1)$$

For internal properties, self-efficacy is defined as:

$$\mathrm{Se(t)} = [\alpha_{se}\,.\,\mathrm{Sc(t)} + (1 - \alpha_{se}).\,\mathrm{Jr(t)}].\left(1 - \mathrm{Np(t)}\right) \quad (2)$$

## IV. SIMULATION RESULTS

Simulation traces have been developed to provide an adequate insight for psychologists. Four different scenarios with variety of conditions have been simulated; high stress event, low stress event, moderate stress event, and high-low stress event. Four main scenarios were simulated ; high stress event with high positive resources, low stress event with high negative resources, moderated stress event with moderate positive and negative resources, high-low stress event. Each scenario has three sub scenarios, where the values of resources were manipulated. Figure 2, 3, 4, and 5 show the simulation results for four different scenarios, how self-efficacy changed based on different scenarios of stress and other properties.

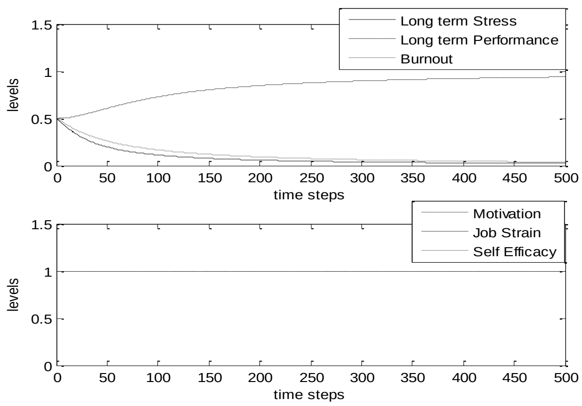


Figure 2: Simulation result for high stress event

As shown in the figure, the two properties (Environmental stressors and Job demands) which leads to a stressed event have been set to high values (having high positive properties and low negative properties). Having the job resources high and social support high with other positive factors, the negative effect of high job demands decreased [8]. The results presented show a high level of performance, with decreased stress and burnout. In addition, the motivation level is high,with increasing level of self-efficacy.

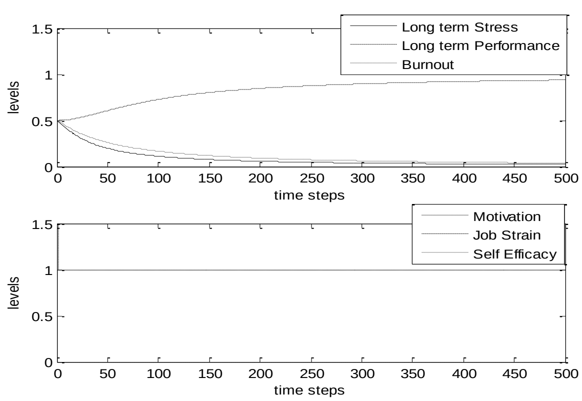


Figure 3: Simulation result for low stress event

For low stress event, result shows low level of stress positively affects the level of performance. In this case, when motivation and self-efficacy levels are high, job strain levels are low, performance of managers will be high.

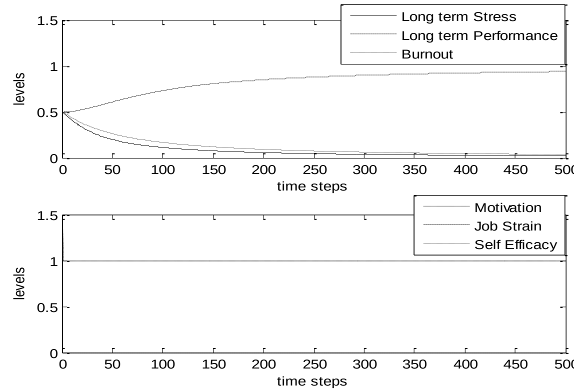


Figure 4: Simulation result for moderate stress event

For moderate stress event, result shows when the stress levels are low, performance level will be high. Motivation and self-efficacy levels are high, which justifies the high level of performance. At the same time, job strain level is low.

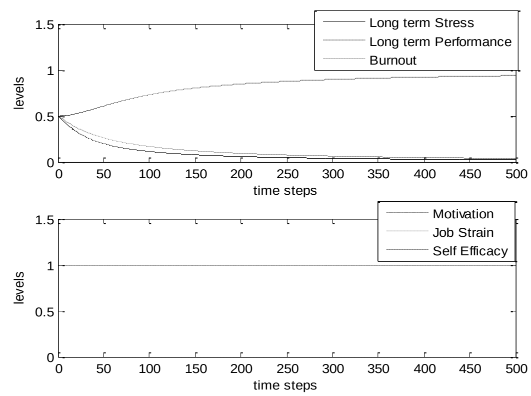


Figure 5: Simulation result for high-low stress event

For high-low stress event, result shows high level of performance, while stress and burnout levels are low. Motivation and self-efficacy levels are high, which contributes to the high level of performance. At the same time, job strain level is low.

## V. MODEL EVALUATION

To evaluate the proposed model, mathematical verification technique has been used to verify the correctness and stability of the model [5] and [9]. Verification is important to ensure model stability by giving constant values to contributed variables. By using this method, time reference is left out. It's worthy to mention that, all exogenous variables are given constant values, and the parameters given a non-zero value. By following all these assumptions of the formal analysis, the following could be concluded. Taking long term stress as an example;

$Ls(t+\Delta t) = Ls(t) + \gamma\_ls.(Ss(t) - Ls(t)).Ls(t).(1 - Ls(t)).\Delta t$

$(dLs(t+\Delta t) - Ls(t))/\Delta t = \gamma\_ls\ (Ss(t) - Ls(t)).Ls(t).(1 - Ls(t))$

$\frac{dLs(t)}{dt} = (Ss - Ls).Ls.(1 - Ls)$

while $\frac{dLs(t)}{dt} = 0$ and $\gamma_{ls} = 1$

Three cases with three different value for long term stress have been simulated (Ls = Ss or Ls = 0 or Ls = 1). The value of Long term stress is either equal to short term stress or one or zero which is a constant value.

**Case #1**: Ls = 1
$sx = \omega_{sx}.Js + \omega_{sx}$

**Case #2:** Ls = Ss
$Sx = \omega_{sx}.Js + \omega_{sx}.Ss$

**Case #3:** Ls = 0
$Sx = \omega_{sx}.Js$

$Lx(t+\Delta t) = Lx(t) + \beta_{lx}.\left[\left(Sx(t) - Lx(t)\right)\right].Lx(t).\left(1 - Lx(t)\right).\Delta t$

$$\frac{dLx(t+\Delta t) - Ls(t)}{\Delta t} = \beta_{lx}\left(Sx(t) - Lx(t)\right).Lx(t).\left(1 - Lx(t)\right)$$

$$\frac{dLx(t)}{dt} = (Sx - Lx).Lx.(1 - Lx)$$

while $\frac{dLs(t)}{dt} = 0$ and $\beta_{lx} = 1$

Therefore Sx=Lx or Lx=0 or Lx=1. The value of Long term exhaustion is either equal to short term exhaustion or one or zero which is a constant value.

Another case is for long term fatigue;

$Lf(t+\Delta t) = Lf(t) + \mu_{lf}.\left[\left(Sf(t) - Lf(t)\right)\right].Lf(t).\left(1 - Lf(t)\right).\Delta t$

$$\frac{dLf(t+\Delta t) - Lf(t)}{\Delta t} = \mu_{lf}\left(Sf(t) - Lf(t)\right).Lf(t).\left(1 - Lf(t)\right)$$

$$\frac{dLf(t)}{dt} = (Sf - Lf).Lf.(1 - Lf)$$

while $\frac{dLs(t)}{dt} = 0$ and $\mu_{lf} = 1$

Three cases with three different value for long term fatigue have been simulated (Sf = Lf or Lf=0 or Lf=1). The value of Long term fatigue is either equal to short term fatigue or one or zero which is a constant value.

**Case#1**: Lf = 1
$Br(t+\Delta t) = Br(t) + \lambda_{br}\left[\left[\omega_{br}.Js + \omega_{br}Cy\right] - Br(t)\right].Br(t).\left(1 - Br(t)\right).\Delta t$

**Case #2:** Lf = Sf
$Br(t+\Delta t) = Br(t) + \lambda_{br}\left[\left[\omega_{br}.Js + \omega_{br}Cy + \omega_{br}.Sf\right] - Br(t)\right].Br(t).\left(1 - Br(t)\right).\Delta t$

**Case #3**: Lf=0
$Br(t+\Delta t) = Br(t) + \lambda_{br}\left[\left[\omega_{br}.Js + \omega_{br}Cy\right] - Br(t)\right].Br(t).\left(1 - Br(t)\right).\Delta t$

$$\frac{dBr(t+\Delta t) - Br(t)}{\Delta t} = \lambda_{br}\left(Gr(t) - Br(t)\right).Br(t).\left(1 - Br(t)\right)$$

By following the assumptions, therefore Gr=Br or Br=0 or Br=1. The value of Burnout is either equal to Gr or one or zero which is a constant value.

**Case #1**: Gr=Br
$Sp(t) = \left[\eta_{sp}.Se(t) + \left(1 - \eta_{sp}\right).Mv(t)\right].\left(1 - Gr(t)\right)$

**Case #2**: Br=0
$Sp(t) = \left[\eta_{sp}.Se(t) + \left(1 - \eta_{sp}\right).Mv(t)\right]$

**Case #3**: Br=1
$Se(t) = \left[\alpha_{se}.Sc(t) + (1 - \alpha_{se}).Jr(t)\right].\left(1 - Np(t)\right)$

Se = 0

[α_(se ).Sc(t)+(1-α_se ).Jr(t) ]. $\left(1 - Np(t)\right) = 0$

$\alpha_{se} = 0.5$ Therefore $0.5\ sc + 0.5\ Jr.(1 - Np)$

$\alpha_{se} = 1$

$Sc + Jr.(1 - Np) = 0$

$(1 - Np) = 0$ Therefore Np=1

where $0.5Jr.(1 - Np) = -0.5Sc$

Then Np = 1, which indicates that when negative personality value is high (1), that will lead to the low value of self-efficacy (0).

## VI. Conclusion

This paper presented a human support agent model which designed based on cognitive theories and its related models. However, neurology aspect and gender variations have not been considered. A human-agent model can be useful to serve as a foundation to design an intelligent software agent that can predict the optimal performance level and support manager when facing critical points to decide the right action during heighten stress [4]. The proposed model could be encapsulated within virtual agents or robots to simulate human-like behaviours for a training environment tool. As a result, this kind of model brings many benefits to new psychologists to acquire more insight pertaining to chronic stress by simulating multiple conditions on digital environments.

This study can be useful for the development of inclusive human resource management, to support the optimum working life through finding solutions on handling stress, and decreasing stress among employees in general and managers in specific. Future works can consider using other evaluation techniques such as mathematical analysis and automated verification to ensure the internal validation of the model.

## ACKNOWLEDGMENT

This research is funded by Universiti Utara Malaysia (UUM) through University grant [SO code: 12575 (2012)]. The authors fully acknowledged UUM for the approved fund which makes this important research viable and effective.


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